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Dynamic Signal Processing

(Incorporated in the United Kingdom)

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(56) Documents Cited  
GB 2256042 A GB 2190192 A GB 1485117 A  
GB 1393122 A WO 88/09560 A1

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H4K KOC  
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(54) Monitoring landfill sites

(57) Parameters on a landfill site, such as local gas or water concentration, ground temperature or the presence of intruders, are monitored remotely by sensor units (44) in suitable locations on the site. Each sensor unit is linked by radio to an on-site control station (38), which may in turn be connected by telephone link to a remote master control station. Each sensor unit has at least one sensor (10) connected to a radio transmitter (18) through a signal processor (14), and transmits when a parameter exceeds a threshold value and/or when interrogated by radio. It is preferably solar powered.

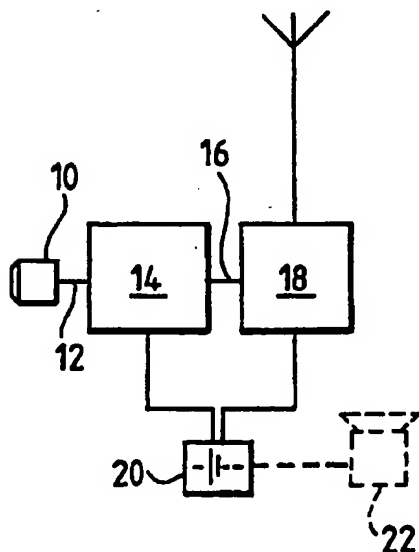


FIG.1.

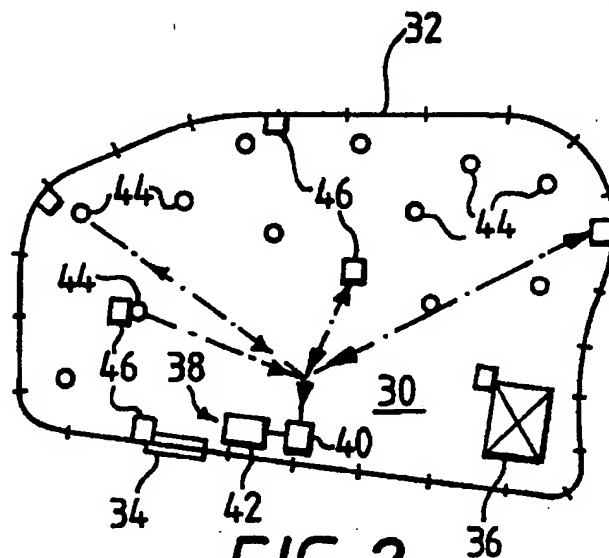


FIG.2.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

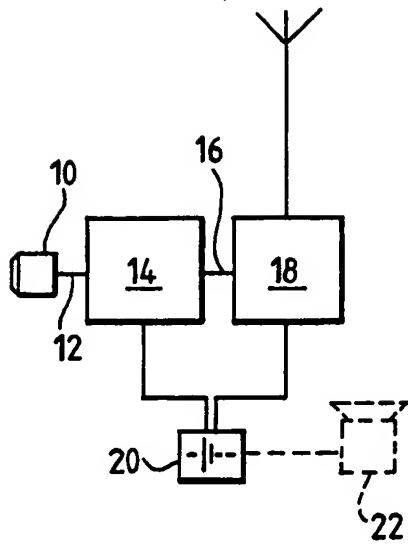


FIG.1.

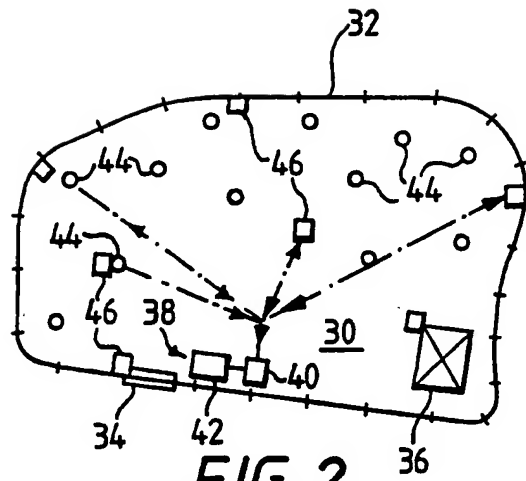


FIG.2.

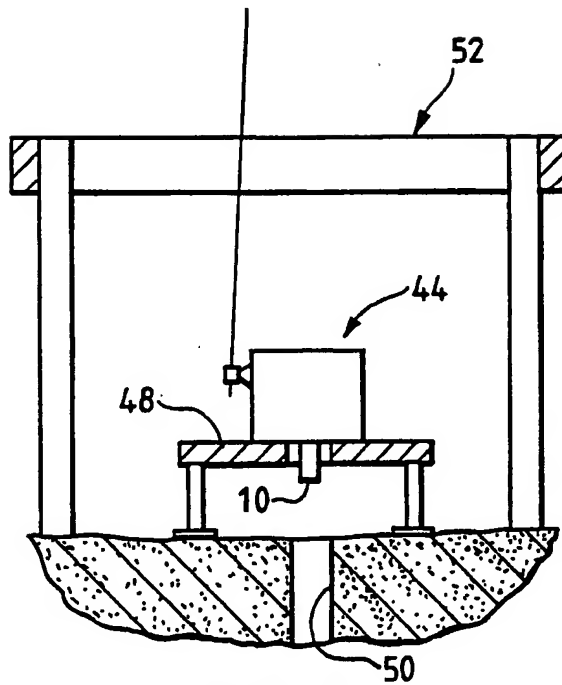


FIG.3.

## MONITORING LANDFILL SITES

This invention relates to the monitoring, on landfill sites, of parameters which may, without limitation, typically comprise the presence, absence and local  
5 concentration of gases, local air or ground temperature, presence or absence of water or toxic liquids, and the presence of intruders.

Landfill sites are sites on which waste is dumped, this waste normally being mechanically compacted so that it  
10 becomes part of the ground, often to a very great depth. The waste usually comprises a wide variety of materials, and will typically include organic matter and/or various other substances which, by chemical interaction or by natural decay, tend to produce  
15 products such as gases which may be toxic or explosive, or otherwise noxious or harmful to the environment, or detrimental to the stability of the site itself.

It is therefore necessary to monitor the various parameters associated with these effects so that any  
20 necessary remedial action can be taken. Sometimes the need for such action is extremely urgent, e.g. if there is a concentration of a gas likely to start a fire spontaneously. The nature of landfill sites is such that there is usually quite a high fire risk.

25 Boreholes are conventionally sunk at various locations on the site, especially in the region of its perimeter with a view to detecting seepage of pollutants into the surrounding land.

Current practice is to monitor landfill sites by  
30 arranging regular inspections (typically at weekly

intervals) by personnel equipped with suitable detecting equipment, who move over the site to measure certain parameters such as those mentioned above, in particular at the boreholes. This reliance on personal monitoring has a number of disadvantages. First, although some landfill sites are manned, so that such inspections can be quite frequent, others are unmanned. On an unmanned site monitoring can only be carried out when someone visits the site, and even then only when that person is actually present. Thus, for example, a fire may break out when nobody is at the site, and may take hold seriously before an alarm can be raised.

In addition, landfill sites, especially unmanned ones, are susceptible to theft of dumped materials, machinery or other equipment, and unauthorised access by intruders is therefore an ever-present problem.

For these reasons it is currently necessary to provide a comparatively large number of personnel to protect a landfill site. It is not safe to leave it unattended for any extended period of time. The labour-intensiveness of maintaining what is after all merely a dump for unwanted waste creates a continuous cost over and above the cost involved in the operations of dumping material on the site. This is especially so after the site is full, and no longer regularly visited in the daytime for the purpose of dumping material.

An object of the present invention is to reduce the manpower requirement. Another object is to provide virtually immediate detection of situations requiring attention, such as unacceptable concentrations of explosive or toxic substances, or the presence of intruders.

According to the invention in a first aspect, a method of monitoring a parameter on a landfill site, comprises: locating at a location on the site a sensor unit having sensing means for the said parameter, 5 signal processing means for producing output signals responsive to signals from the sensor means representing the state of the parameter, and a transmitter for automatically transmitting radio signals representing output signals of the processing 10 means; receiving the radio signals at a central control station; and processing the information conveyed thereby.

In a second aspect, the invention provides a sensor unit as defined above.

15 The central control station is preferably on the site itself. It comprises a radio receiver coupled to a suitable processor, such as a computer programmed to analyse the signals received from a number of the sensor units located in different places on the site, 20 and to cause (in any suitable way) information to be disseminated about the state of the parameter or parameters (usually the latter) being monitored. This dissemination may for example be by way of an audible or visual indication.

25 The on-site control station may be one of several on different landfill sites, incorporating transmitting means for relaying the information to a receiver feeding a further signal processing means at a master control station. The master control station can be 30 some way from the various sites, and will normally be manned. The information from what may be a large number of sensor units on the various sites is then

available continuously to the operator at the master station, who can arrange for any remedial action to be taken, immediately if the information indicates an emergency. The link between one on-site control station and the master station may be an ordinary or dedicated telephone link.

The processing means in any sensor unit, and/or the processor at the on-site control station, and/or that at the master station if any, can be programmed in any suitable way. For example, each sensor unit may be arranged to transmit a radio signal in connection with a particular parameter, say the local temperature, or the concentration of a particular gas, if it exceeds a predetermined threshold value.

Preferably, however, each sensor unit includes radio receiving means, the central control station having radio transmitting means and its processor being programmed so as to send regular interrogation signals to the sensor units so as to monitor the correct operation of the latter.

In any case, it may be desired to obtain continuous information, or information at predetermined intervals (e.g. once every minute, or once every hour) from each sensor unit. The on-site control station processor and those in the sensor units can readily be arranged in known ways to perform this function, with that at the master station being similarly programmed if required.

The sensor units fall basically into two categories: borehole sensor units (BSU) and security sensor units (SSU). A borehole sensor unit will be placed in or close to a borehole on the site, and may contain a

number of sensors, typically with each sensor adapted to react to a different parameter. The processing means is then such as to recognise and distinguish the output signals of the various sensors. The radio  
5 signals from the unit will of course contain information identifying the parameter on which information is being sent.

The sensors in the borehole sensor units may typically be of known kinds sensitive to: atmospheric  
10 concentration of oxygen, carbon dioxide or methane; relative humidity; water level; temperature; atmospheric pressure.

There may be more than one SSU on each site, positioned for example on plant, machines, buildings or gates, or  
15 close to one or more of the borehole sensor units. The SSU sensor or sensors may be of any known type, for example the active or passive infra-red type, or the vibration, magnetic or contact types.

A sensor unit according to the invention may if desired  
20 be both a BSU and an SSU, having appropriate sensor means and signal processing means connected to a common radio transceiver.

Each sensor unit (of whatever kind) is preferably self-powered by means of a battery, preferably rechargeable,  
25 and may incorporate recharging means which is preferably of a known automatic type, e.g. a solar pack. The processing means of each unit is preferably arranged in a known way to transmit output signals, either automatically, e.g. continuously or at regular  
30 intervals, or on receipt of an interrogation signal from or via the on-site control station, indicating

whether or not there is a fault in the unit, and/or a  
tamper alarm signal.

The system may also include a security paging unit of  
any known kind, which can be carried by anyone within  
5 radio range of one or more sensor units. This paging  
unit will normally be in radio communication with the  
on-site control station. It could also be linked by  
radio to the sensor units, so as to give an audible  
and/or visual alarm in response to a signal from a  
10 sensor unit indicating the possible presence of an  
intruder and/or the fact that a predetermined threshold  
value of one of the physical parameters (gas  
concentration etc.) is being exceeded.

An embodiment of the invention will now be described,  
15 by way of example only and with reference to the  
accompanying drawings, in which:-

Figure 1 is a simplified block diagram of a sensor  
unit;

Figure 2 is a plan of a typical landfill site; and

20 Figure 3 is a simplified sectional elevation showing  
one arrangement for siting a borehole sensor unit.

The unit shown in Figure 1 is described in terms of a  
BSU, but it is to be understood that it may equally  
well be an SSU. It comprises a sensor head 10  
25 containing several sensors (not shown) for detecting  
and measuring a variety of parameters such as those  
mentioned above. The output signals from the head 10,  
at 12, are processed by a processor 14, which generates  
a digital output signal at 16 when the value of any one  
30 of the parameters exceeds a threshold value. This



output signal is coded so as to identify the parameter and its instantaneous value and/or rate of change.

The signals at 16 are transmitted by a radio transceiver 18. Both the processor 14 and transceiver 18 are powered by a rechargeable battery pack 20, optionally kept charged by a solar recharging unit indicated at 22.

The site 30 in Figure 2 has a perimeter security fence 32 with a gate 34, and contains a plant shed 36 and a gatehouse (not shown) in which is an on-site central control station 38 comprising a radio transceiver 40 connected to a central processor 42. A number of boreholes are drilled in various locations on the site. A BSU 44, indicated by a small circle in Figure 2, is located in or adjacent to each borehole. A number of security sensor units 46, each indicated by a solid square in Figure 2, are arranged around the site in suitable positions. The two-way radio links between various sensor units 44, 46 and the transceiver 40 are indicated in phantom lines.

Figure 3 shows one of many possible ways of mounting a BSU 44 at a borehole. The unit 44 has a weatherproof casing, and its sensor head 10, in this example, projects downwardly from the base of the casing, through an opening in a support platform 48 so as to lie over the borehole, indicated at 50. A protective fence 52 is arranged around the borehole, as protection against collision by plant moving around the site.

**CLAIMS**

1. A method of monitoring a parameter on a landfill site, comprising: providing at a location on the site a sensor unit having sensing means for the said  
5 parameter, local signal processing means for producing output signals responsive to signals from the sensor means representing the state of the parameter, and a transmitter for transmitting radio signals representing output signals of the local processing means;  
10 receiving the radio signals at a control station; and processing the information conveyed thereby.
2. A method according to Claim 1, for a site where the control station is on the same site, wherein the  
15 information is analysed and disseminated at the on-site control station by a second processing means coupled to a receiver for the radio signals.
3. A method according to Claim 2, wherein  
20 dissemination of the analysed information comprises transmitting the latter by telephone link to a master control station.
4. A method according to Claim 3, for monitoring a  
25 parameter on a plurality of landfill sites, each having at least one said sensor unit and a said control station, including receiving the analysed information from each site by telephone link at the master control station.
5. A method according to any one of the preceding  
30 Claims, for a site having a plurality of the said sensor units disposed in various locations on the site, the radio receiver at the control station receiving

said output signals from all the sensor units on the site.

5 6. A method according to any one of the preceding Claims, for monitoring a plurality of parameters, at least one of the sensor units on the site having sensing means for two or more of the said parameters, the output signals being such as to distinguish the parameters from each other, with the second processing means analysing and disseminating information about  
10 each parameter.

15 7. A method according to any one of the preceding Claims, including the further step of transmitting interrogation signals from the control station to the sensor unit, so that the latter receives them as radio signals and, in response thereto, transmits a said output signal to the control station.

8. A method according to Claim 7, including transmitting the interrogation signals automatically and at predetermined intervals.

20 9. A method according to any one of Claims 1 to 6, wherein the local signal processing means are programmed with a predetermined threshold value of the said parameter, the sensor unit producing a said radio signal automatically when the parameter as detected by  
25 the associated sensing means exceeds the threshold value.

30 10. A sensor unit at a landfill site for use, by a method according to any one of the preceding Claims, in monitoring at least one parameter, including: sensing means for the said parameter or parameters; local

signal processing means connected to the sensing means for producing output signals responsive to signals from the sensing means representing the state of the or each parameter; a transmitter connected to the processing means for transmitting radio signals representing the said output signals; and power supply means for the sensing means, local signal processing means and transmitter.

11. A sensor unit according to Claim 10, wherein the power supply means comprise means for converting solar energy to electrical energy.

12. A sensor unit according to Claim 11, wherein the power supply means further include at least one rechargeable electric battery coupled to the solar conversion means so as to be charged by the latter.

13. A sensor unit according to any one of Claims 10 to 12, further including a radio receiver for receiving interrogation signals, the local signal processing means being adapted to transmit a said radio signal in response to a said interrogation signal.

14. A sensor unit according to any one of Claims 10 to 13, wherein the local signal processing means is adapted to cause a said radio signal to be transmitted when the value of at least one parameter, as detected by the sensing means, exceeds a predetermined threshold value.

15. A method of monitoring at least one parameter on at least one landfill site, substantially as described in the foregoing description with reference to the accompanying drawings.

16. A method according to any one of Claims 1 to 9 or Claim 15, further including providing a paging unit at the site for receiving output signals from said sensor units on the site and/or in radio communication with the control station to receive signals therefrom; and giving an alarm by means of the paging unit in response to a said signal indicating the possible presence of an intruder or that a predetermined threshold value of a said parameter is exceeded.
17. Apparatus for monitoring at least one parameter on a landfill site, arranged and adapted to operate substantially as described in the foregoing description with reference to the accompanying drawings.

- 12 -

Patents Act 1977  
Examiner's report to the Comptroller under Section 17  
(The Search report)

Application number  
GB 9226400.1

**Relevant Technical Fields**

(i) UK Cl (Ed.L) G4H (HNEA, HNEB, HNEC, HNED, HNEE, HNEF, HNEG, HNEH, HNEJ, HNEL, HNEM, HNHE), H4K (KOC)

(ii) Int Cl (Ed.5) G08B

Search Examiner  
M J DAVIS

Date of completion of Search  
13 OCTOBER 1993

**Databases (see below)**

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-  
1-17

**Categories of documents**

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2256042 A (SIEMENS PLESSEY) - whole document	1-17
X	GB 2190192 A (NEWTON) - whole document	1-17
X	GB 1485117 (EMI) - whole document	1-17
X	GB 1393122 (WESTINGHOUSE ELECTRIC) - whole document	1-17
X	WO 88/09560 A1 (BATTELLE) - whole document	1-17

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

## DETAILED ACTION

### *Election/Restrictions*

1. Restriction to one of the following inventions is required under 35 U.S.C. § 121:
  - I. Claims 1-17, drawn to an electronic system for use on a remote gas or oil well-site, classified in class 73, subclass 31.01.
  - II. Claim 18, drawn to method of initializing a system having a central communications interface, classified in class 340, subclass 286.01.

The inventions are distinct, each from the other because of the following reasons:

2. Inventions I and II are unrelated. Inventions are unrelated if it can be shown that they are not disclosed as capable of use together and they have different modes of operation, different functions, or different effects (MPEP § 806.04, MPEP § 808.01). In the instant case the different inventions consist of an apparatus/system (Group I), and a method of initializing a central communications system and it's elements.
3. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.
4. During a telephone conversation with Mr. Andrew Hicks on 21 September 2004 a provisional election was made without traverse to prosecute the invention of Group I, claims 1-17. Affirmation of this election must be made by applicant in replying to this Office action. Claim 18 is withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

***Claim Rejections - 35 USC § 112***

5. The following is a quotation of the first paragraph of 35 U.S.C. § 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

6. Claim 17 is rejected under 35 U.S.C. § 112, first paragraph, as based on a disclosure which is not enabling. The “intrinsically safe housing” critical or essential to the practice of the invention, but not included in the claim(s) is not enabled by the disclosure. See *In re Mayhew*, 527 F.2d 1229, 188 USPQ 356 (CCPA 1976). The instant specification and/or claims completely fail to enable one of ordinary skill in the art to understand, make, or utilize an “intrinsically safe housing,” since the disclosure fails to provide any details and or specifications of exactly what constitutes an “intrinsically safe housing,” and what part of the claimed “system” utilizes this so-called “intrinsically safe housing.”

***Claim Rejections - 35 USC § 103***

7. The following is a quotation of 35 U.S.C. § 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

8. Claims 1, 2, 4 and 8-17 are rejected under 35 U.S.C. § 103(a) as being unpatentable over US 6,670,887 to Dungan and US 6,405,135 to Adrian et al. Dungan discloses an electronic system (Figs. 1-19) for use on a remote gas or oil well-site to detect and identify gas present in the atmosphere and transmit to location off-site data respecting the gas so identified; the system



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having: at least one sensor means (38) to detect and generate raw data respecting at least one noxious gas (including hydrogen sulfide and sulfur dioxide and their LEL level or ppm) (Dungan: col. 9, lines 37-43, and col. 1, lines 26-29 as recited in claims 11 and 16) present in the atmosphere; means to process the raw data (via analog-to-digital conversion (290) and identify each noxious gas detected (Dungan: col. 9, lines 9-11); a central/master communication interface (18) (which may be mobile) for electronically receiving the data via a receiver/transceiver (74) from the sensors, and relays for transmitting offsite (118) (see Fig. 4), wireless local means (UHF, radio signals operating at any desired frequency, licensed or unlicensed) (248) (Dungan: col. 16, lines 17-24) (as recited in claim 12) to communicate to the central communication interface data representing the noxious gases detected; and a portable source of electrical power (note: portable sources of power, such as batteries, back-up power supplies are common and well known sources of electrical power for electronic devices), as well as solar power means for charging (Dungan: col. 12, lines 35-42 & col. 15, lines 4-22) (as recited in claim 10); means for sensing atmospheric conditions that cause anomalous output for the sensor means (Dungan: col. 10, line 62 to col. 11, line 5) (as recited in claim 2) and intrinsically safe housings (Dungan: table, col. 11) (as recited in claim 17). Dungan further discloses employment of long distance wireless communication means (i.e. more powerful wireless signal means with higher gains than cellular phone antennas or UHF) via a satellite dish and low-earth-orbit (LEO) satellites and wherein when data messages are transmitted to the LEO satellite from the sensor means, it may be linked to a local gateway for validation and optimal routing to the recipient which would be the central/master communication interface (Dungan: col. 6, line 50 to col. 7, line 48).

Dungan does not expressly disclose the employment of the Internet (World Wide Web)

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for the transmission of data in conjunction with the local/long distance wireless means (as recited in claim 1); including voice communication means (as recited in claim 4) means of storing and processing the raw data for the purposes of creating a data log respecting the nature and presence or concentration of at least one noxious gas over time (as recited in claim 9) and various aspects of wireless communications means recited in claims 13-15). Adrian et al. disclose a system and method for monitoring pollutants/contaminants within the environment (Figs. 1-6) having sensors (10) to measure the presence of the pollutants/contaminants employing the Internet (23) and Web site system (22) including storage/database to record events (as recited in claim 9), the Web/Internet communication system having secure/confidential notifications offsite to responsible parties (24), an Internet domain (i.e. IP address, as recited in claim 8) name utilized by the detections service provider using standard protocols to form a global distributed network (thus including common elements recited in claims 13-15), communications means (including voice (Adrian et al.: col. 6, line 62) (as recited in claim 4); transmitting data via lines (17), satellite relay or wireless digital communication. It would have been obvious to one having ordinary skill in the art at the time the invention was made to employ the Internet as a data communication means, as taught by Adrian et al., thus modifying the electronic system disclosed by Dungan, thus providing enhanced communication means in real time via the Internet.

9. Claims 3 and 5-7 are rejected under 35 U.S.C. § 103(a) as being unpatentable over US 6,670,887 to Dungan and US 6,405,135 to Adrian et al. as applied to claim 1 above, and further in view of US 6,259,956 to Myers et al. Dungan and Adrian et al. disclose an electronic system having all of the elements stated previously. Dungan and Adrian et al. do not expressly disclose

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an electronic system further including a camera for taking video/digital images and their transmission (as recited in claim 3, means for detecting signal strength and suitable switching means for the long-distance wireless means (as recited in claims 5 and 6); and a call center at the off-site location. Myers et al. disclose an storage site monitoring system (Figs. 1-6) having Internet communication means via a Web server (40a) receiving information from various sensors (2, 28) for creating a HTML log (46) and reports (44) for transmitting data offsite via a call center (40b); including video cameras (52) taking digital images of the remote site which are converted to HTML image files and hyperlinked to related HTML text files (as recited in claim 3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to employ a camera/video system and a call center, as taught by Myers et al., thus modifying the electronic system disclosed by Dungan and Adrian et al., thus providing means to visually monitor the various sensor site locations remotely. In specific regards to claims 5 and 6, providing means to measure signal strength and switching means is considered an obvious variant well within the purview of design choice of one of ordinary skill in the art, for ordinary cell-phones have indicators of signal strength and automatic switching means to provide wireless communications.

### ***Conclusion***

10. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. See PTO 892 form for Prior Art discussing various aspects of the instant invention.

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Fitzgerald whose telephone number is (571) 272-2843. The examiner can normally be reached on Monday-Friday from 7:00 AM to 3:30 PM. If attempts to

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reach the examiner by telephone are unsuccessful, the examiner's supervisor, Hezron Williams, can be reached on (571) 272-2208. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

JF

10/16/2004